COMMENTARY

MRI conditional pacemakers: the start of a new era

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This is a commentary on the short communication by Raj et al [1] in this issue of the *British Journal of Radiology* (BJR).

The first rule of all radiology departments is that a pacemaker is a contraindication to MR scanning. Quite rightly, we go to great lengths in routine clinical practice to ensure that patients with an *in situ* pacemaker do not enter the scanning suite. This involves the clinical referrer signing part of the request card indicating there is no known contraindication to MR and rigorous questioning of the patient by the MR department radiographers and support staff before they are allowed into the controlled scanning area. There are several theoretical risks if a patient with a pacemaker undergoes an MRI examination [2]. Firstly the electronic circuits of the pacing box may malfunction and effectively be erased, particularly by the static magnetic field, which leads to a lack of pacing that could be life-threatening in a patient who is pacemaker dependent. Secondly, the rapidly changing magnetic field gradients may induce currents in the pacing system, which can lead to hyperstimulation and rapid over-pacing causing a negligible cardiac output. The radiofrequency (RF) pulse may also do this to some degree. Thirdly, the pacing box or lead may move as a result of the strength of the static magnetic field if there are ferromagnetic components within the pacing system. Finally, there is a risk that the pacing electrode, acting as an antenna, will absorb the RF pulses and localise this energy in the electrode tip as heat, which might burn and potentially rupture the myocardium, particularly given the thin walls of the right-sided cardiac chambers.

Across the world, several hundred patients have inadvertently undergone an MR examination despite having a pacemaker in place [3]. In the majority of cases there were no untoward events, which suggests that the actual risk is low. However, deaths have occurred and although there is little conclusive evidence, the identification of

ventricular fibrillation in some of these patients suggests dysrhythmia owing to rapid chaotic pacing as a likely cause of death. It seems that none of these deaths occurred when there was a physician present directly supervising or monitoring the scan [2]. In several published small studies of patients knowingly undergoing MR examinations with pacemakers *in situ* there were no reported deaths, although these studies have clearly been performed in highly specialised institutions [4].

In practical terms, once an individual patient has a permanent pacemaker inserted they will never be able to undergo an MR scan for the rest of their lives. Although pacing boxes can be changed, the pacing leads are essentially permanent. This is problematic for these patients, given the recent data that states there is a 50–75% chance of a patient with a pacemaker or implanted cardiac defibrillator needing an MR scan at some point in their life [5]. As a result, pacing technology manufacturers have focused their research for some time on developing an MR compatible pacing system. Although such systems are in various stages of development, one device, the SureScan (Medtronic, Minneapolis, MN) pacing system, has been shown to be safe under specific conditions in a large cohort of patients and is available for use in clinical practice [6, 7]. There are several principles to its safety. Firstly, the lead has been designed to be a poor conductor of RF energy; secondly, the internal circuitry of the pacing system has been improved to lessen the chance of cardiac stimulation and disruption of the internal power supply; and thirdly, the pacing box can be specifically set to an MR-safe mode for the purposes of the scan and then reset afterwards. These pacing systems have a safety rating of “MR conditional” because there are constraints on the conditions of their use *i.e.* they are safe only under certain well-defined conditions.

The SureScan device has largely been tested, in published literature, on patients undergoing MR of the brain or lumbar spine. MR examinations of the heart and thorax have been seen as the ultimate test of this device given that the pacing system is entirely within the imaging field. A number of patients with this pacing system have successfully undergone cardiac MRI (CMRI). In this

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month's *BJR*, Raj et al [1] present elegant MRIs of one of these pacing leads situated in the RV during a CMR study. They also detail the strict safety requirements for a patient undergoing this examination, equivalent to the conditions that make this device MR conditional. The indications for CMR, in a patient with one of these pacing devices present, remains to be determined and it is not yet clear whether the image quality will be good enough to, for example, assess reliably for an RV dysplasia.

This is a new era indeed, but this is only the start. In the early stages of clinical use it seems appropriate that all MR scans in patients with this device *in situ* are performed in regional cardiac units, with support from the local MR physics department and the manufacturers. It is clearly essential for an electrophysiology technician to be present to programme and reprogramme the device before and after the scan and it would seem appropriate in these early stages for a cardiologist to also be present for the scan. Raj et al [1] are right to emphasise the multidisciplinary approach required in the use of these pacing systems as the radiologist cannot and must never be left to manage these cases alone. There needs to be a rigorous process of checks prior to MR scanning to ensure the patient's safety. One can foresee difficulties with patients apparently having a safe device but with very little confirmatory documentation being present. Although the manufacturers have designed the pacing box and the electrodes to have characteristic markings that can be identified on a radiograph, it cannot be overstated that there is no point in having an MRI compatible pacing box if the leads are MRI unsafe. Finally, cardiologists need to be reminded and encouraged to insert these devices, particularly if there is a high likelihood of the patient needing an MR scan in the future that can be predicted at the time of pacemaker insertion. This surely is an opportunity to create reliable local documentation, which is easily identifiable in the patient's notes, that the device is MR compatible so that future MR scans can be planned in confidence. The manufacturer currently provides a system of recommended checks, documentation and advice, but this process will become more complex as

more of these devices come onto the market from different manufacturers. It is likely, therefore, that local and national guidelines will be required because the stakes are high if the strict safety measures that these devices require are not followed to the letter. The message must remain — if in doubt, don't scan.

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